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(54) **SPEECH ANALYSIS AND THERAPY SYSTEM AND METHOD**

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(58) **Field of Search** 704/271; 434/258

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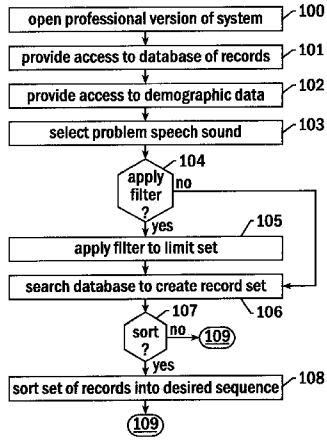
(57) **ABSTRACT**

A system and method for analyzing a speech problem includes the steps of presenting to a student/user a symbol representative of a word and prompting the user to pronounce the word represented by the symbol into a microphone in signal communication with a processor. Next the therapist enters a phonetic representation of the user pronunciation into the processor. It is then automatically determined whether an error exists in the user pronunciation. If an error exists, the error is automatically categorized. The system and method may be adapted for presentation of a single word, a plurality of words having a predetermined feature desired to be tested, a pretest for screening for potential articulation disorders, and an analysis of connected speech with the use of a moving picture to elicit a narrative from the student.

28 Claims, 4 Drawing Sheets



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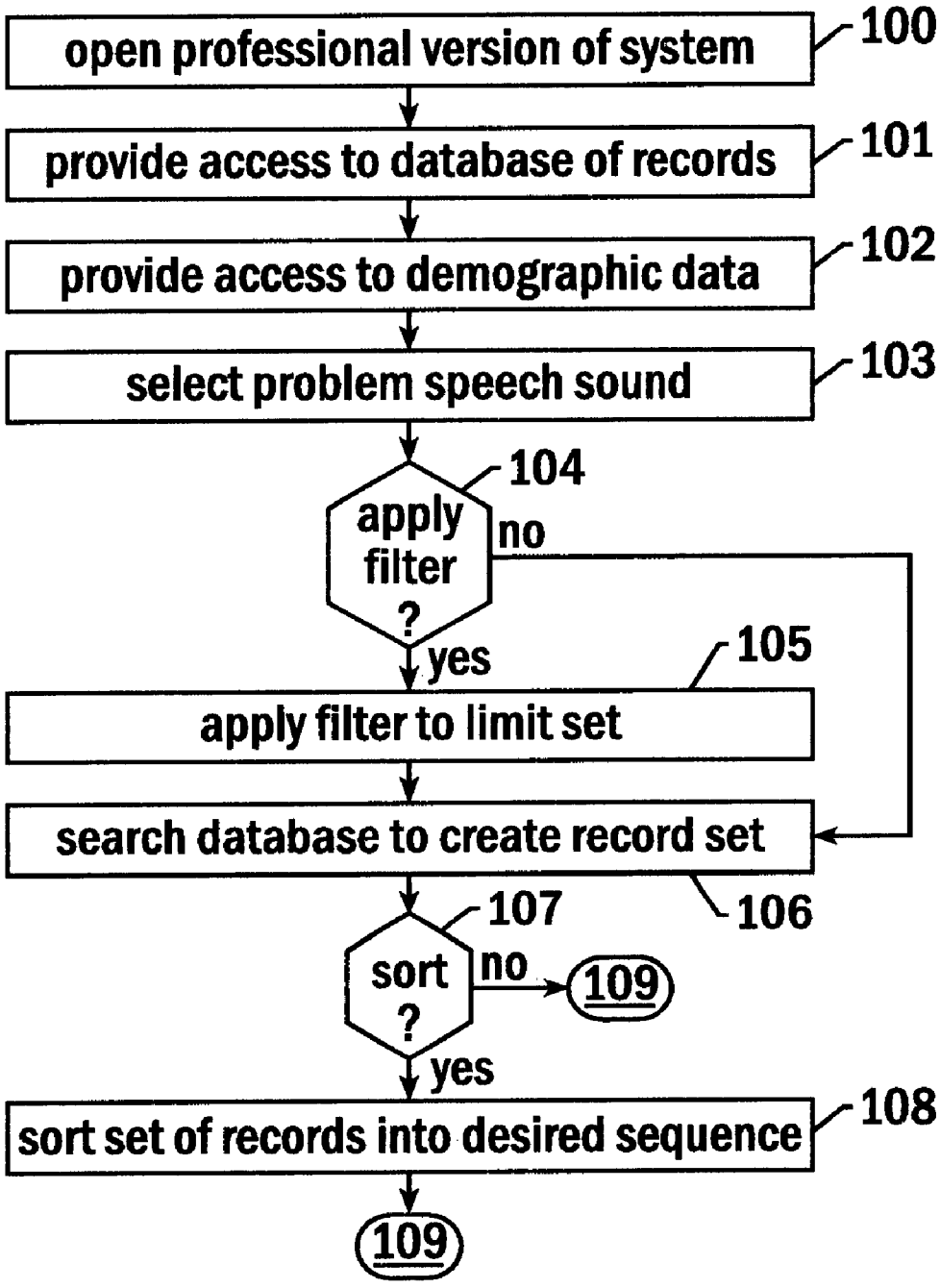
open professional version of system
100
provide access to database of records
101
provide access to demographic data
102
select problem speech sound
103
apply filter ?
104
no
yes
105
apply filter to limit set
search database to create record set
106
sort ?
107
no
109
yes
sort set of records into desired sequence
108
109

FIG. 1A.

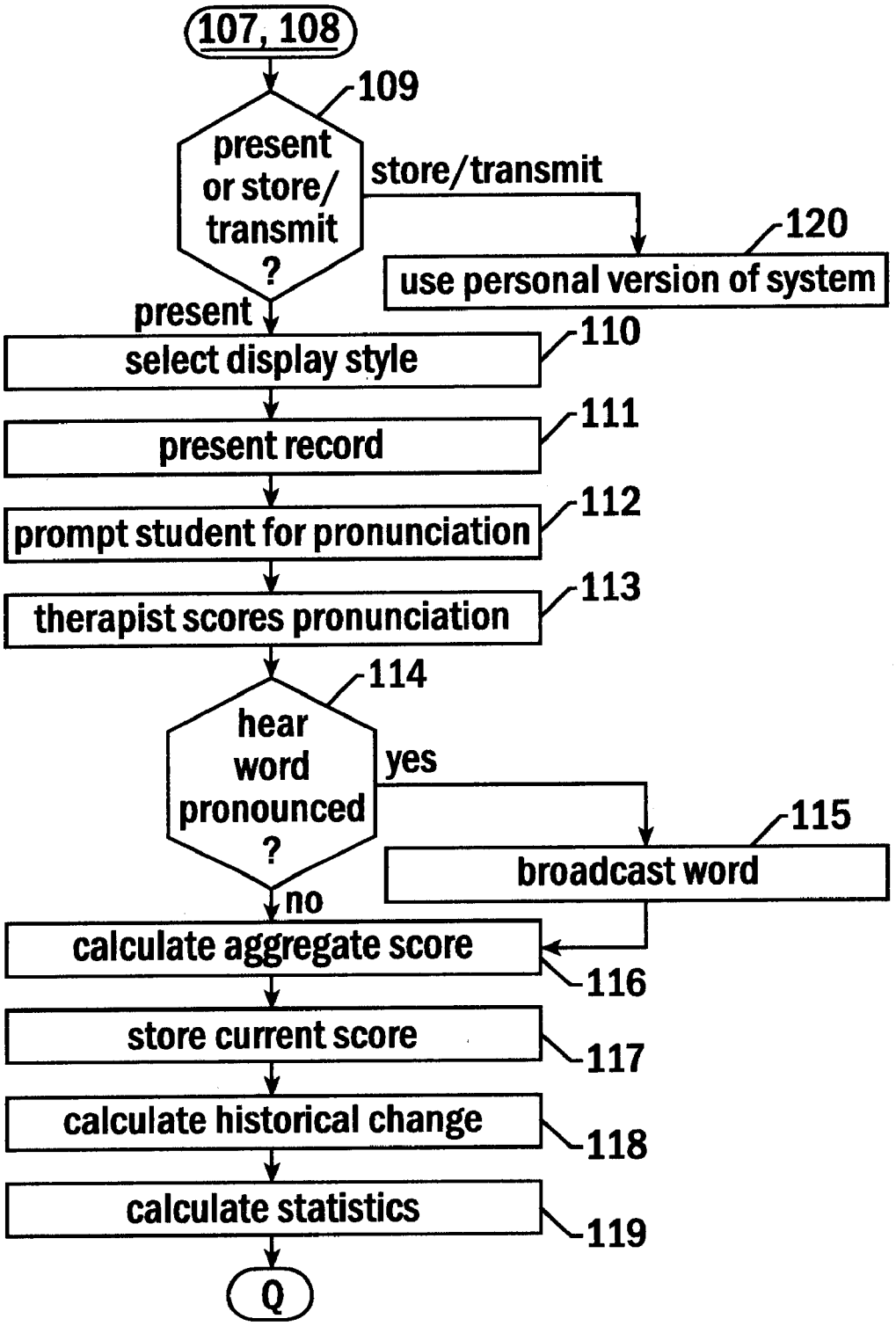
107, 108
109
present or store/ transmit ?
store/transmit
120
use personal version of system
present
110
select display style
111
present record
112
prompt student for pronunciation
113
therapist scores pronunciation
114
hear word pronounced ?
yes
115
broadcast word
no
calculate aggregate score
116
store current score
117
calculate historical change
118
calculate statistics
119
Q

FIG. 1B.

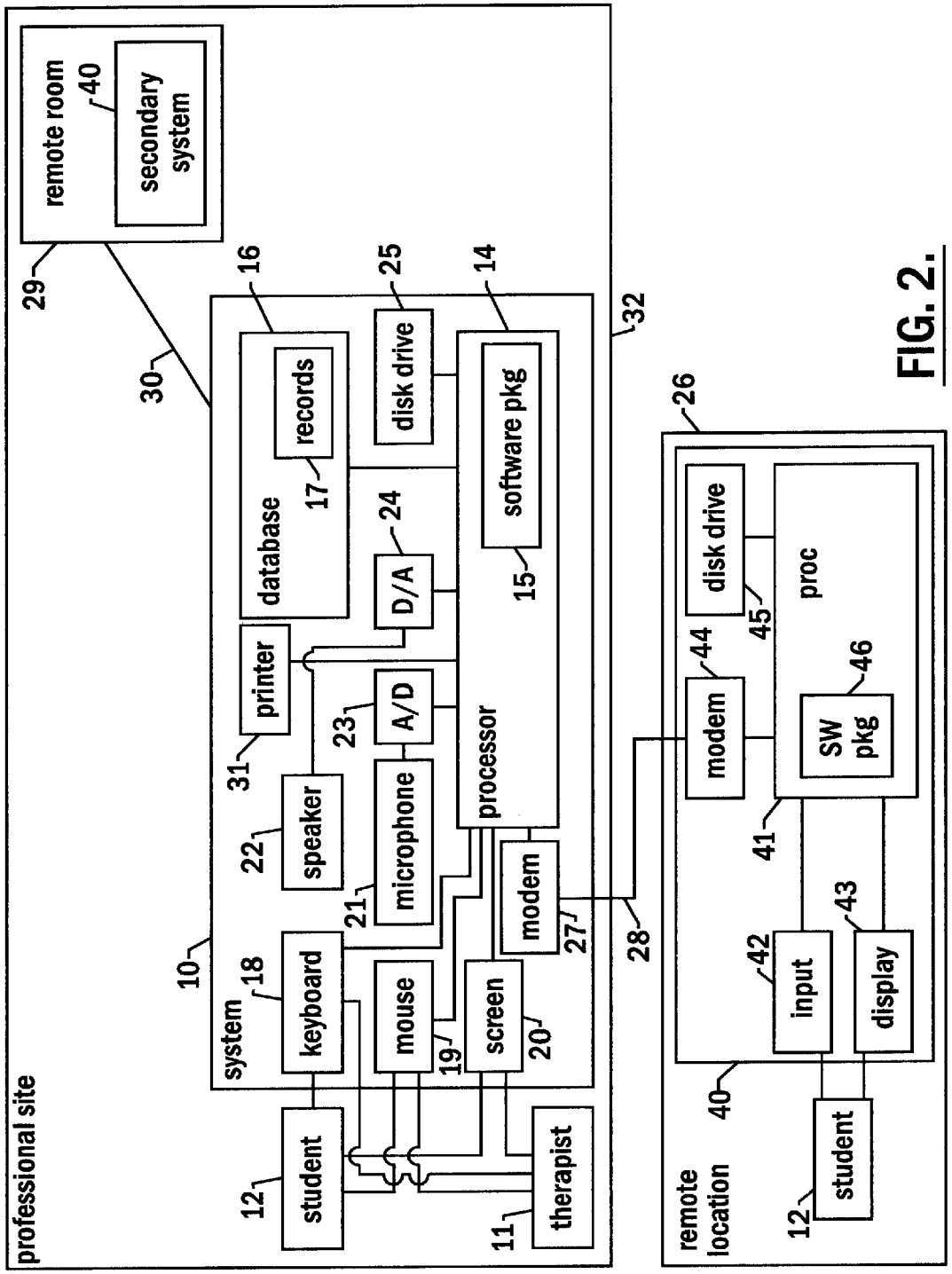
professional site
remote room
40
secondary system
29
30
16
25
14
32
database
records
17
disk drive
software pkg
15
D/A
24
printer
31
A/D
23
speaker
22
microphone
21
processor
modem
27
10
system
18
keyboard
mouse
19
screen
20
12
student
11
therapist
28
26
disk drive
45
proc
modem
44
SW pkg
46
41
42
input
43
display
remote location
40
12
student

FIG. 2.

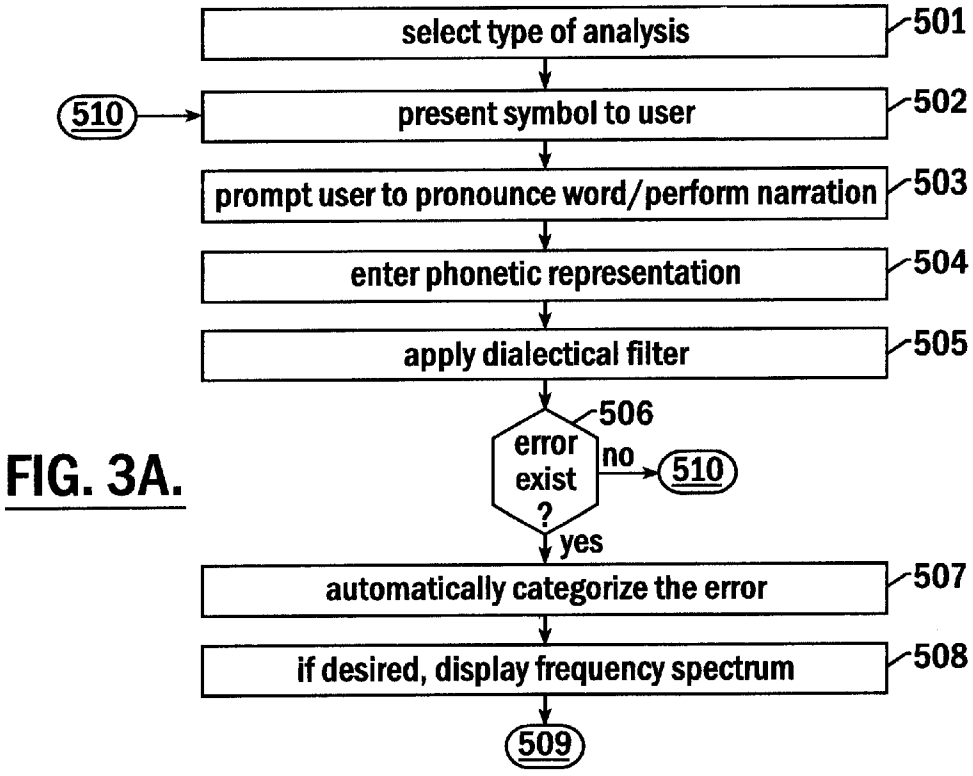
select type of analysis
501
510
present symbol to user
502
prompt user to pronounce word/perform narration
503
enter phonetic representation
504
apply dialectical filter
505
506
error exist ?
no
510
yes
automatically categorize the error
507
if desired, display frequency spectrum
508
509

FIG. 3A.

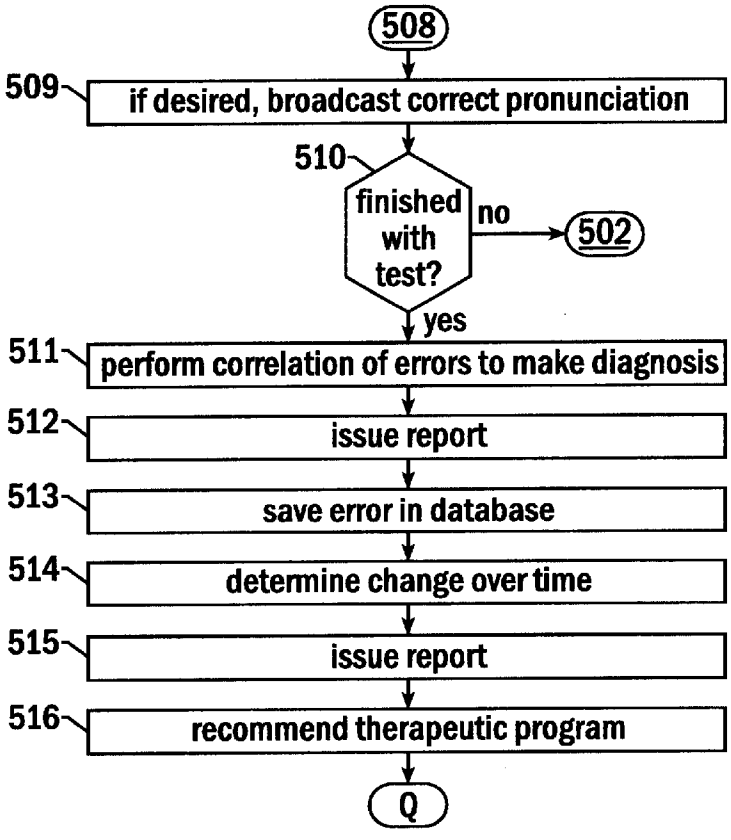
508
509
if desired, broadcast correct pronunciation
510
finished with test?
no
502
yes
511
perform correlation of errors to make diagnosis
512
issue report
513
save error in database
514
determine change over time
515
issue report
516
recommend therapeutic program
Q

FIG. 3B.

SPEECH ANALYSIS AND THERAPY SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to systems and methods for analyzing and remediating speech pathologies, and, more particularly, to such systems and methods that are computer-based.

2. Description of Related Art

Articulation and phonology disorders are the most common of the speech and language disorders. The prevalence of this disorder is, at the time of writing, approximately 10% of the school-age population. In addressing a perceived articulation issue in a student, speech/language pathologists have in the past used an initial test based upon a series of cards. Each card contains a picture and a word, and the student is asked to pronounce the word associated with the card. The pathologist then determines whether the student's pronunciation is "right" or "wrong." It may be recognized that such a system can be cumbersome, owing to the cards' having to be placed in a desired order and sorted manually.

An intervention system designed to automate this process, Picture Gallery I, was presented by the owner of the current application. In this system pictures and/or words stored in a database could be sorted using a desired criterion such as a particular phoneme and presented to the student under software control for facilitating the acquisition or remediation of speech or language skills. No analysis or scoring is performed; rather, the product is intended for use by one or more students, either alone or in concert with a pathologist/teacher.

A previously known method of diagnosing articulation or phonology disorders included a "pencil and paper" test wherein a student is asked to speak a word. The therapist grades the word subjectively, based upon the therapist's ear and the local standards.

Other systems known in the art that address speech/language analysis and therapy methodologies includes those of Neuhaus (U.S. Pat. No. 6,113,393), Parry et al. (U.S. Pat. No. 6,077,085), UCSF and Rutgers (U.S. Pat. Nos. 5,813,862 and 6,071,123), Neumeyer et al. (U.S. Pat. No. 6,055,498), Jenkins et al. (U.S. Pat. Nos. 5,927,988 and 6,019,607), Siegel (U.S. Pat. No. 6,009,397), Beard et al. (U.S. Pat. No. 5,857,173), Aaron et al. (U.S. Pat. No. 5,832,441), Russell et al. (U.S. Pat. Nos. 5,679,001 and 5,791,904), Rothenberg (U.S. Pat. No. 5,717,828), Wen (U.S. Pat. No. 5,562,453), and Ezawa et al. (U.S. Pat. No. 4,969,194). Commercial software products in the field of articulation, phonology, or speech sound production include SpeechViewer, Interactive System for Phonological Analysis, Speech Master, Visi-pitch, and Computerized Profiling. Commercial print products include the Goldman-Fristoe Test of Articulation (American Guidance Service), Khan-Lewis Test of Phonology (American Guidance Service), Photo Articulation Test (Pro-Ed), and Fisher-Logeman Test of Articulation (Pro-Ed).

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a system and method for eliciting a desired sound from a user.

It is a further object to provide such a system and method adapted to generate a report.

It is another object to provide a system and method for testing a user's articulation.

It is an additional object to provide such a system and method that is adapted to analyze a group of problematic sounds.

It is yet a further object to provide such a system and method that recommends a therapeutic program responsive to the analysis.

It is yet another object to provide such a system and method that includes a prescreening feature.

These and other objects are achieved by the present invention, a first aspect of which comprises a method and system for providing speech therapy. The method comprises the steps of selecting a problem speech sound and searching a database that comprises a plurality of records. Each record comprises a picture and a word associated with the word.

Next a set of records is automatically generated from the plurality of records. Each record contains a word specific to the problem speech's sound. The set of records is next automatically presented to a user sequentially on a display device, and the user is prompted to pronounce the displayed word. Finally, the pronunciation of each word is scored.

The system of the first aspect of the present invention comprises a processor, an input device in communication with the processor having means for selecting a problem speech sound, and a display device in communication with the processor. The database as described above is resident on the processor, as are software means. The software is adapted to automatically generate a set of records from the plurality of records, with each record containing a word specific to the problem speech sound. The software is also adapted to automatically present at least a portion of each record in the set of records to a user sequentially on a display device; the set of records to a user sequentially on the display device and to prompt the user to pronounce the displayed word. Finally, the software is adapted to receive via the input device a score for the pronunciation of each word.

Another aspect of the present invention is a system and method for analyzing a speech problem by performing a test of articulation, phonology, and sound features that is administered and analyzed with the use of an electronic processor. This method comprises the steps of presenting to a student/user a symbol representative of a word and prompting the user to pronounce the word represented by the symbol into a microphone in signal communication with a processor. Next the therapist enters a phonetic representation of the user pronunciation into the processor. It is then automatically determined whether an error exists in the user pronunciation. If an error exists, the error is automatically categorized.

The system of the second aspect of the invention evaluates an articulation disorder. The system comprises a processor and an output device and an input device, each in signal communication with the processor.

Software installable on the processor is adapted to present on the output device, typically a display device, although this is not intended as a limitation, a symbol representative of a word. The software then is adapted to prompt a user via the output device to pronounce the word represented by the symbol and to receive from the therapist via the input device a phonetic representation of the user's pronunciation. The software automatically determines whether an error exists in the user pronunciation, and, if an error exists, automatically categorizes the error.

The system and method of this second feature of the invention may be adapted for presentation of a single word,

a plurality of words having a predetermined feature desired to be tested, a pretest for screening for potential articulation disorders, and an analysis of connected speech with the use of a moving picture to elicit a narrative from the student.

The features that characterize the invention, both as to organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description used in conjunction with the accompanying drawing. It is to be expressly understood that the drawing is for the purpose of illustration and description and is not intended as a definition of the limits of the invention. These and other objects attained, and advantages offered, by the present invention will become more fully apparent as the description that now follows is read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A,1B** is a flow chart for an exemplary embodiment of the speech therapy method of the invention.

FIG. **2** is a schematic diagram of the speech therapy system.

FIGS. **3A,3B** is a flow chart for an exemplary embodiment of the speech analysis method of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description of the preferred embodiments of the present invention will now be presented with reference to FIGS. **1A–3B**.

A flow chart of an exemplary embodiment of the automated speech therapy/intervention method is given in FIGS. **1A,1B**, and a schematic of the system in FIG. **2**. The system and method are also contemplated for use in the acquisition of a language skill as well as in a remediation setting. There are two versions of the system and method: In the "professional" version **10** of the invention (block **100**), typically two people who will be referred to as "therapist" **11** and "student" **12** are present, although this is not intended as a limitation. This version is contemplated for use in such settings **32** as a hospital, clinic, rehabilitation center, school, or private facility. In the "personal" version **40** of the invention, the "student" **12** may be working alone, or in the presence of a nonprofessional such as a parent. The therapist **11** may be, for example, a speech therapist or a teacher; the student **12** may be a user who is learning a second language or a school attendee who is being tested for, or who is already known to have, an articulation problem or phonological disorder.

The method comprises the steps of providing access to an electronic database that includes a plurality of records (block **101**). Each record comprises a word, a picture representative of the word, and a recommended pronunciation of the word. In an alternate embodiment, the record may also include a digitized video clip to represent motion or a verb to impart a concept of action. In another embodiment the record may further include a digitized sound that is associated with the word. For example, the record for the word dog might contain a picture of a dog, a video clip of a dog running, and/or a barking sound. It is believed that such multiple stimuli appeal to a multiplicity of cognitive areas, thereby optimizing the student's improvement.

Each record may further contain data useful for performing sorting functions, such as at least one category and/or concept. An exemplary set of categories comprises: animals, art, babies, celebrations, global images, environment, family, food, garden, health and exercise, home, leisure, medical, money, music, pets, play, school, shopping, signs/symbols, sports, technical, vacations, and work. An exemplary set of concepts comprises: activities, objects, places, people, ideas, and events. The record also typically comprises a vocabulary level associated with the word and a length of the word.

The method next comprises the step of inputting or accessing previously input demographic information for the student (block **102**). Then a problem speech sound that is desired to be improved upon is selected that is known from a prior diagnosis (block **103**). The problem speech sound may be selected from a group consisting of a phoneme and a "feature." The feature comprises at least one of a place, a manner, and a voicing characteristic. Searching on a feature yields matches in all positions of words. The database is electronically searched (block **106**) for records containing words that include the problem speech sound to generate a set of records. A filter may be applied if desired (block **104**) to further limit the set (block **105**), including selecting a category or concept, using the demographic information to limit the set, such as eliminating words that are intended for students over 7 years of age for a 5-year-old student, setting a desired vocabulary level, or selecting a word length.

If desired (block **107**), the set of records may also be sorted (block **108**) in various ways to produce a desired sequence, including, but not limited to, putting the words in alphabetical order, random order, or some other chosen sequence. In a preferred embodiment, all the words in the database contain at least one of the letters "r," "l," and "s" since these are known to present a problem most frequently.

For a professional therapy session, a decision may be made whether to present the set of records or store/transmit them (block **109**). If the former, the set of records is next presented sequentially to the student in the predetermined sequence on a display device (block **111**), and the student is prompted to pronounce the word (block **112**). The display style may be selected (block **110**) from a word only, a picture only, or a word plus a picture.

If the student can read, he or she can use the displayed word to form a pronunciation; if the student cannot yet read, or cannot read the currently presented language, the picture will also aid in acquisition of reading skills as well as pronunciation.

In the professional setting, the therapist scores the student's pronunciation (block **113**) by inputting, for example, "correct," "incorrect," "skip," or "re-present," which will record an indication to re-present the record at a later time, such as after all the other items in the set have been presented. The student or therapist can also elect (block **114**) to hear the word pronounced (block **115**) in a recommended manner by making an appropriate selection on an input device.

The scores are received by the system, and an aggregate score is calculated (block **116**) for the problem speech sound. The database also comprises a historical record of all sessions for each of the students, and the database is then accessed to store the current score thereinto (block **117**). The therapist may choose to calculate a historical change (block **118**) from previously saved scores to provide an indication of the student's progress. Such scores may also be used to calculate statistics (block **119**) for a group of students, using, for example, a demographic filter.

The "personal version" of the system and method does not accept scoring, nor is there a database from which sets of records may be created. Rather, the professional version is

adapted to download a selected set of records onto a storage medium, such as a diskette, or to transmit the set of records to a remote site (block **109**). Such a remote site may comprise, but is not intended to be limited to, a room remote from the main processor accessible via intranet, or a different building accessible via internet. This version then enables the student to perform (block **120**) the steps in blocks **110–112** and **115** as desired on his or her own.

The system **10**, as schematically illustrated in FIG. **2**, comprises a processor **14**, on which are resident the software package **15** of the present invention adapted to perform the functions as outlined above and a database **16** comprising the plurality of records **17** and demographic and historical data on the users **12**. An input device is in communication with the processor **14** that has means for selecting a problem speech sound. Such means may comprise any of the devices known in the art such as a keyboard **18** or pointing device such as a mouse **19** or touch screen. A display device such as a display screen **20** is also in communication with the processor **14**.

Optional elements that are also in communication with the processor **14** may include a microphone **21** and a speaker **22**, both under processor **14** control, as well as means for performing analog-to-digital **23** and digital-to-analog **24** conversions. The system **10** also has means for transferring records from the database to a storage medium such as a disk drive **25**, under control of the software **15**, or to a remote site such as another location **26** via a modem **27** over the internet **28** or such as another room **29** at the same location via an intranet **30**. A printer **31** under processor control may also be provided for furnishing a hard copy of any portion of the session as desired.

A secondary system **40** for use of the personal version of the invention at the remote location **26,29** comprises a processor **41**, input device **42** and display device **43** in communication with the processor **41**, and either or both of a modem **44** for receiving a set of records and a storage device reader **45** for reading a stored set of records. The software package **46** for this version is adapted to read the records, present them to the student **12** sequentially, and prompt the student **12** to pronounce the word associated with the record.

A flow chart of an exemplary embodiment of the automated speech therapy/intervention method is given in FIGS. **3A–3**. The schematic of the system is substantially the same as that in FIG. **2**. The method comprises the steps of selecting the type of evaluation desired to be performed (block **501**): screening, single word analysis, "deep" test, or connected speech analysis. The screening, or pre-evaluation, comprises the steps of presenting to a user a symbol representative of a word (block **502**) and prompting the user to pronounce the word represented by the symbol into a microphone in signal communication with a processor (block **503**). The symbol presentation may comprise, for example, a picture on a display screen, although this is not intended as a limitation. The therapist then enters a phonetic representation of the user pronunciation into the processor (block **504**). Software installed upon the processor then automatically determines whether an error exists in the user pronunciation (block **506**). The determination may additionally include the application of a dialectical filter (block **505**) that is adapted to discriminate between that which is deemed to be a true error and a predetermined normal dialect word pronunciation. If an error exists, the software automatically categorizes the error (block **507**). An error may be, for example, a substitution, a mispronunciation, or an omission. These steps are repeated a predetermined number of times n, for example, 20 times (block **510**).

It may then be desired to perform the "deep test," which may be performed with the knowledge gained from a pre-evaluation as above or de novo. If the pre-evaluation has been performed, the software automatically generates a set of symbols, wherein each symbol is representative of a word containing at least one of the errors determined in the pre-evaluation. Then the steps as above are performed using the generated set of symbols, and an evaluation is made of articulation errors for the whole set.

If a single word is desired to be analyzed for, the steps in blocks **502–509** are performed once for the desired word.

Once a word has been pronounced and the phonetic representation entered into the processor, the therapist may decide to display a frequency spectrum of the user's pronunciation (block **508**). If desired, a sample of a correct pronunciation of the word may be broadcast via a speaker in signal communication with the processor (block **509**).

When a plurality of words have been tested, the evaluating step also comprises automatically recognizing an underlying commonality by correlating the errors detected. This pattern recognition permits the software to achieve an overarching diagnosis of a problem speech sound (block **511**).

Following the error categorization, if desired, a report can be issued detailing the user's error(s) (block **512**). Additionally, the error may be saved in a database that is accessible by the processor (block **513**). If a previous entry for this user already exists, which is determined by a search, the error found in the present test may be compared with an error previously found, and a change over time determined for that user (block **514**), to note whether an improvement has occurred. Again, if desired, a report may be issued (block **515**) as to the change determined.

An additional feature of this invention is the ability, once a categorization has been made of an error, of recommending a therapeutic program to address the error (block **516**). Such a recommendation formulation may comprise, for example, creating a set of records as detailed above in FIGS. **1A–2**.

If connected speech analysis is desired to be performed, the "symbol" comprises a motion picture representative of an action, and the user is prompted to provide a narration on the action into a microphone in signal communication with a processor. The therapist then enters a phonetic representation of the user's pronunciation of the narration into the processor. Software resident in the processor automatically determines whether an error exists in the user pronunciation, and, if an error exists, automatically categorizes the error.

It may be appreciated by one skilled in the art that additional embodiments may be contemplated, including alternate forms of presentation of the symbols and sounds.

In the foregoing description, certain terms have been used for brevity, clarity, and understanding, but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such words are used for description purposes herein and are intended to be broadly construed. Moreover, the embodiments of the apparatus illustrated and described herein are by way of example, and the scope of the invention is not limited to the exact details of construction.

Having now described the invention, the construction, the operation and use of preferred embodiment thereof, and the advantageous new and useful results obtained thereby, the new and useful constructions, and reasonable mechanical equivalents thereof obvious to those skilled in the art, are set forth in the appended claims.

What is claimed is:

1. A method for evaluating an articulation disorder comprising the steps of:

presenting to a user a symbol representative of a word;

prompting the user to pronounce the word represented by the symbol into a microphone in signal communication with a processor;

entering a phonetic representation of the user pronunciation of the word into the processor;

automatically determining whether an error exists in the user pronunciation; and if an error exists, automatically categorizing the error.

2. The method recited in claim 1, further comprising the step, following the prompting step, of displaying a frequency spectrum of the user pronunciation.

3. The method recited in claim 1, further comprising the step, following the prompting step, of broad casting a sample of a correct pronunciation of the word.

4. The method recited in claim 1, further comprising the step of issuing a report on an error in user pronunciation.

5. The method recited in claim 1, further comprising the steps of:

saving the error in a database accessible by the processor;

searching the database to determine whether a previous entry for the user exists; and

if a previous entry exists, comparing the error with an error in the previous entry and determining a change with time.

6. The method recited in claim 5, further comprising the step of issuing a report on the determined change.

7. The method recited in claim 1, further comprising the step, if an error exists, of recommending a therapeutic program to address the error.

8. The method recited in claim 7, wherein the program recommending step comprises the steps of:

searching a database comprising a plurality of records, each record comprising a picture and a word associated therewith; and

automatically generating a set of records from the plurality of records, each record containing a word containing a problem speech sound representative of the error, the set of records for subsequent display and pronunciation by the user.

9. The method recited in claim 1, wherein the presenting step comprises displaying a picture on a display screen.

10. The method recited in claim 1, wherein the error is selected from a group consisting of a substitution, a mispronunciation, and an omission.

11. The method recited in claim 1, wherein the determining step comprises applying a dialectical filter adapted to discriminate between an error and a predetermined normal dialect word pronunciation.

12. A method for evaluating an articulation disorder comprising the steps of:

performing a pre-evaluation comprising the steps of:

(a) presenting to a user a symbol representative of a word;

(b) prompting the user to pronounce the word represented by the symbol into a microphone in signal communication with a processor;

(c) entering a phonetic representation of the user pronunciation of the word into the processor;

(d) automatically determining whether an error exists in the user pronunciation; and

(e) if an error exists, automatically categorizing the error;

repeating steps (a)–(e) a predetermined number of times;

automatically generating a set of symbols, each symbol representative of a word containing at least one of the errors determined in the pre-evaluation; and

performing an evaluation comprising performing steps (a)–(e) using the generated set of symbols.

13. The method recited in claim 12, further comprising automatically generating a report summarizing the errors detected in the evaluation performing step.

14. The method recited in claim 12, wherein the evaluation performing step comprises automatically recognizing an underlying commonality in the errors to achieve a diagnosis of a problem speech sound.

15. The method recited in claim 14, further comprising the step of recommending a therapeutic program to address the diagnosed problem speech sound.

16. A method for evaluating an articulation disorder comprising the steps of:

(a) presenting to a user a symbol representative of a word;

(b) prompting the user to pronounce the word represented by the symbol into a microphone in signal communication with a processor;

(c) entering a phonetic representation of the user pronunciation of the word into the processor;

(d) automatically determining whether an error exists in the user pronunciation;

(e) if an error exists, automatically categorizing the error; repeating steps (a)–(e) a predetermined number of times; and

correlating the categorized errors to determine an existence of an articulation disorder.

17. A method for evaluating an articulation disorder comprising the steps of:

presenting to a user a motion picture representative of an action;

prompting the user to provide a narration on the action into a microphone in signal communication with a processor;

entering a phonetic representation of the user pronunciation of the narration into the processor;

automatically determining whether an error exists in the user pronunciation; and

if an error exists, automatically categorizing the error.

18. A system for evaluating an articulation disorder comprising:

a processor:

an output device and an input device, each in signal communication with the processor;

software means installable on the processor adapted to:

present on the output device a symbol representative of a word;

prompt a user via the output device to pronounce the word represented by the symbol;

receive via the input device a phonetic representation of the user pronunciation of the word;

automatically determine whether an error exists in the user pronunciation; and

if an error exists, automatically categorize the error.

19. The system recited in claim 18, wherein the display device comprises at least one of a printer and a display screen and the input device comprises at least one of a keyboard, a pointing device, and a microphone.

20. The system recited in claim 18, wherein the software means is further adapted to display on the display device a frequency spectrum of the user pronunciation.

21. The system recited in claim 18, further comprising broadcasting means in signal communication with the processor and wherein the software means is further adapted to direct a sample of a correct pronunciation of the word to be broadcast via the broadcast means.

22. The system recited in claim 21, wherein the broadcasting means comprises an audio speaker.

23. The system recited in claim 18, wherein the software means is further adapted to issue a report on an error in user pronunciation via the display device.

24. The system recited in claim 18, wherein the software means is further adapted, if an error exists, to recommend a therapeutic program to address the error.

25. The system recited in claim 24, further comprising a database resident on the processor comprising a plurality of records, each record comprising a picture and a word associated therewith; and

wherein the software means is further adapted to automatically generate a set of records from the plurality of records, each record containing a word containing a problem speech sound representative of the error, the set of records for subsequent display and pronunciation by the user.

26. The system recited in claim 18, wherein the symbol comprises a picture and the output device comprises a display screen.

27. The system recited in claim 18, wherein the output device comprises a display screen, and wherein the software is adapted to direct a presentation of a motion picture representative of an action on the display screen.

28. A method for evaluating an articulation disorder comprising the steps of:

presenting to a user a symbol representative of a word;

prompting the user to pronounce the word represented by the symbol;

entering a phonetic representation of the user pronunciation of the word into the processor;

automatically determining whether an error exists in the user pronunciation; and

if an error exists, automatically categorizing the error.

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